OS41N-13 1150h

Internal waves and plume fate in a coastal stratified environment off Huntington Beach

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We address the observed signature of internal waves (IW) near the beach and connects it with concurrent data. The internal wave effect was clearly visible in high resolution photographs. The IW were observed very close to the beach (O(100m) m away) and their effect on local transport was stronger than either surface swell or alongshore advection. We propose that IW may be the dominating factor determining the fate of pollutants in the near shore zone off Huntington Beach area under typical conditions. We have analytically determined the properties and fate of long internal waves origating at the shelf break (60 m deep water) and finishing in the surf zone -approximately 5-10 m deep water. The analysis of IW properties is complemented with remote hyperspectral data with from aerial photographs and Synthetic Aperture Radar (SAR). This approach together with mooring data provides a synoptic picture and general idea about internal wave generation and propagation and impact on surf zone transport. In addition we numerically examine plume behavior associated with discharge of sewage of Orange County Sanitation District (OCSD). We have used Direct Numerical Simulation (DNS) and Large Eddy Simulations (LES) programs currently used to simulate and predict behavior of OCSD outfall plume under different conditions.

OS41O HC: 316 C Thursday 0830h

Transport and Transformation of Biogeochemically Important Materials in Coastal Waters IV

Presiding: **J L Largier,** Scripps Institution of Oceanography**; J A Barth,** College of Oceanic and Atmospheric Science

OS41O-01 0835h

Oceanic and Atmospheric Structure and Evolution Observed by Aircraft During COAST 2001

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Twenty-seven flights with an instrumented aircraft were made to observe the structure and evolution of the ocean and lower atmosphere over the Oregon continental margin during the COAST summer 2001 field program. Flights were executed in a manner that coordinated with and extended measurements made by the COAST ship and moored instrumentation efforts. Aircraft measurements were made of oceanic surface temperature, oceanic subsurface temperature to depths up to 500m, upper-ocean color, atmospheric wind, temperature, humidity and pressure.

Atmospheric structure varied throughout the summer on periods ranging from diurnal to several days (the atmospheric synoptic scale), and an atmospheric temperature inversion typically, though not always, developed during episodes of northerly winds. An inversion rarely accompanied southerly winds. The principal oceanic response to atmospheric forcing was the onset of upwelling during sustained northerly wind events. The persistence of upwelled conditions for a number of days after the demise of northerlies (and sometimes the change to southerlies) was observed in ocean temperature and color fields. The nearshore upwelling band and separated upwelling jet over Heceta Bank were clearly delineated in the oceanic temperature field, and the chlorophyll field, as indicated by upper-ocean color data, followed these patterns. Small, nearshore regions of elevated chlorophyll concentrations were also seen and were related to terrestrial effects such as outflows from coastal rivers and lagoons. These and other characteristics will be discussed in detail in this presentation.

URL: http://www.marine.unc.edu/cool/coast

OS41O-02 0850h

The Coastal Ocean Response to Summertime Downwelling Favorable Winds off Oregon

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On the strongly wind-driven continental margin of the northeast Pacific ocean, seasonal upwelling drives high biological productivity. During the summer when winds are generally upwelling favorable, there are periods when the winds are weak ("relaxed") or strongly downwelling favorable. During June 2000 and again in August 2001, the oceanic and ecosystem response off Oregon to strong summertime downwelling was observed. During the downwelling event, northward winds lasted 3-4 days and reached speeds of up to 40 knots. The surface layer warmed by about 4C over the entire continental shelf as warm oceanic surface water was advected onshore. The southward upwelling jet and the accompanying tilted isopycnals that existed before the downwelling event persisted, but were located over the mid- to outer shelf. Downwelled isopycnals were found within 15 km of the coast. Northward currents in excess of 0.2 m s^{-1} were found inshore of the 70 m isobath and were continuous over the entire study region (130 km alongshore). Prior to the downwelling event, chlorophyll fluorescence was confined to the upper 20 m and was highest adjacent to the coast. During strong northward winds, high chlorophyll was downwelled with the isopycnals near the coast. Chlorophyll was distributed throughout the water column in water depths less than about 70 m. Details of the time evolution of the coupled physical and biological response to summertime downwelling will be presented. The response to strong downwelling favorable winds is compared with that accompanying wind relaxation. In the latter, N-S pressure gradients, e.g. as created by flow-topography interaction, can drive inshore flow northward, but without the accompanying downwelled isopycnals.

URL: http://damp.oce.orst.edu/coast

OS41O-03 0905h

Effects of Topography on Currents During an Upwelling Relaxation Event

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Upwelling events along the west coast of North America are separated by relaxation events in which the winds weaken or even reverse to downwelling-favorable. These events influence alongshore and cross-shelf transport, including larval dispersal. Upwelling conditions tend to produce southward and offshore advection, while downwelling conditions tend to produce northward and onshore advection. Eddies and other mesoscale current features modify these larger-scale advection patterns.

A sequence including upwelling, reversal to downwelling, and return to upwelling occurred in May 1996 near Cape Blanco, Oregon. Wind measurements indicate upwelling-favorable conditions through May 16, 1996. On May 17-18, 1996 a storm moved through the area with strong downwelling-favorable winds. After the storm, winds again were upwelling-favorable. During this period, a Seasonde coastal-based radar system measured surface currents in the Cape Blanco area, extending approximately 40km offshore by 30km alongshore. CTD casts, Seasoar tows, and mooring data provide subsurface data during this period. These data provide detailed observations of current behavior throughout the upwelling event and subsequent wind reversal, including the formation of an anticyclonic eddy over a topographic high, which reverses to cyclonic when winds return to upwelling-favorable. These detailed observations provide an opportunity for analysis of the dynamics behind formation of an eddy over a topographic high and its impact on cross-shelf transport.

OS41O-04 0920h

Model simulations of Eulerian and Lagrangian aspects of the upwelling circulation over the Oregon shelf

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Time-dependent, three dimensional circulation on the continental shelf off Oregon is studied using the Princeton Ocean Model (POM). The objective is to combine Eulerian and Lagrangian analyses to better understand water particle movement associated with the temporal and spatial variability of upwelling dynamics on the Oregon shelf. The Lagrangian analysis is implemented through the calculation of the evolution of three conservative tracer fields that are initialized, respectively, with each of the three model coordinates. Ideally, this allows calculation of water particle displacement for every particle. A limited-area high resolution curvilinear grid ($\triangle$x, $\triangle$y<1.5 km, σ=45) with realistic Oregon bottom topography is used. A model domain with periodic alongshore boundary conditions is chosen for the study. The response of the coastal ocean during summer 1999 upwelling conditions to forcing by observed wind stress and heat flux is examined. The model-produced alongshore velocities compare favorably with ADCP current measurements, with better agreement found on the inner shelf. The model fields show that the large variations of the shelf bottom topography associated with Heceta Bank and the large variations of the coastline provided by Cape Blanco exert major influences on the shelf circulation and the associated density fields. The time mean surface temperature field indicates stronger upwelling over Heceta Bank and south of Cape Blanco. The Lagrangian analysis shows significant alongshore variation in the onshore paths of upwelled water. In particular, intensified onshore and vertical displacements of water particles are found over Heceta Bank and south of Cape Blanco, coincident with the locations of stronger upwelling. Relatively large onshore flows in the interior of the water column over the shelf are found in these locations. An examination of Eulerian term balances in the alongshore momentum equation shows that stronger onshore flows in these regions are associated with a northward pressure gradient force. Strong nonlinear advective effects in the coastal jet along the western edge of the bank contribute to the generation of a northward ageostrophic pressure gradient force and to the formation of a local cyclonic circulation. Lagrangian analysis shows that onshore flow occurs in the bottom boundary layer on the southern edge of the bank. The southward transport of water at the surface veers offshore following the isobaths over the bank, while northward transport of water particles occurs at depth south of the bank.

OS41O-05 0935h

Microstructure Measurements From a Towed Undulating Platform and Their Relationship to Mesoscale Circulation and Bottom Topography

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Compared with conventional free-falling profilers, the use of a microstructure instrument on a towed, undulating platform, such as the recently-developed MicroSoar, allows for a more rapid survey of the distribution and magnitude of turbulence over a larger area. Such an overview is clearly important in our effort to understand the interplay between wind events, turbulence, and mesoscale circulation. One of the specific hypotheses to be tested by the Coastal Ocean Advances in Shelf Transport (COAST) experiment, whose broad aim is to examine the effect of wind-driven processes on cross-shelf transport off the Oregon coast, is that patterns of turbulence on the shelf during both upwelling and downwelling conditions are influenced by fronts and jets, and the levels of turbulence can reach sufficient intensity to influence the mesoscale circulation.

In 2001, as part of the COAST experiment, MicroSoar was used to obtain the widespread measurements of the turbulence field which allow this hypothesis to be explored. Values of the temperature variance dissipation rate (χ) and overturning (Thorpe) scales from the MicroSoar data reveal the distribution of turbulence relative to both the coastal jet and bottom topographic features. These turbulence measurements compare favorably to those made with a traditional free-falling instrument at the same time and location.

URL: http://damp.oce.orst.edu/coast/highres.shtml

OS41O-06 0950h

Examining the Occurrence of Phosphate-Stress in Coastal Phytoplankton Communities Using a Cell-Specific Enzymatic Assay

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As part of the CoOP COAST project, a multi-PI and multi-disciplinary effort, water column samples from May and August 2001 cruises to the Oregon shelf are being analyzed for nutrient inventories, chlorophyll-a, and Alkaline phosphatase (APase) activity. One objective of our study is to evaluate the physiological state of the phytoplankton regarding phosphate stress. The primary tool we use for evaluating phosphate stress is the APase enzyme. Production of this enzyme is typically induced in phytoplankton when they are stressed by low environmental phosphate levels. As such, the presence of this enzyme can serve as an indicator of phosphate-stress, or phosphate-limitation.

APase data from the May cruise indicated that some groups of phytoplankton on the Oregon shelf were experiencing phosphate-stress. These data were generated using a cell-specific APase assay known as Enzyme Labeled Fluorescence, or ELF. This method involves tagging cells with a fluorescent precipitate at sites of APase activity. Subsequent examination of cells using epifluorescent microscopy reveals which cells are expressing APase, and thus permits resolution of differences in phytoplankton physiological condition at the genus or species level. For example, in some cases we observed different species of diatoms, within the same sample, where one species exhibits extensive ELF-APase activity the other species does not. Observations such as this suggest that different species of phytoplankton may exhibit variable physiological responses to the same external nutrient environment.

OS41O-07 1025h

Surface Flow Patterns in the Bodega-Reyes Region During CoOP/WEST.

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One of the key questions of the interdisciplinary CoOP/WEST (Wind Events and Shelf Transport) study of wind-driven controls on shelf productivity is the transport of near-surface plankton. Even with the intensity of prior physical oceanographic studies in this region, mooring arrays have not been able to resolve the spatial detail of flow structures that account for cross-shelf transport and the opportunities for plankton to withstand export from a relatively narrow shelf. As part of WEST and in collaboration with the Bodega Marine Lab, we have installed two surface radar units (CODAR) to complement data obtained from surface drifters, moored ADCPs and ADCP surveys. While all data types will be described, much of these data are not yet available and primary attention will be given to surface flow patterns elucidated by radar and drifter data. The results show that surface flow is not neatly alongshore and that transient eddy-like flow features are not uncommon. Further, temporal variability in wind and current results in reversals in alongshore flow and it appears that some plankton may be retained over the shelf for periods significantly longer than that estimated from averaged mooring data. These results are put into the spatial context of upwelling near a cape and into the temporal context of an upwelling-relaxation cycle. The most notable cross-shore flows are associated with topographic features and with the non-steady nature of flows that alternate between upwelling and relaxation phases. None of these opportunities for cross-shore transport or retention appear in the classical 2-dimensional view of upwelling.

URL: http://www.ccs.ucsd.edu/coop/west/

OS41O-08 1040h

Preliminary Analysis of CODAR Data on Surface Circulation off Bodega Bay, 2001

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Through a collaboration with the CoOP/WEST program, Bodega Marine Lab has purchased and installed two CODAR units - one at Bodega and the other south near Point Reyes. These units have operated continuously since May 2001 and provide an invaluable view of surface flow patterns in this upwelling region. It is anticipated that a third unit will be deployed north of Bodega in late 2001. We will review data quality procedures and present some preliminary views of the data - both visualization of time-dependent patterns and statistical analysis of the surface flow field. These results will be related to concurrent observations of near-surface flow in the Bodega-Reyes region. Data collected to-date show evidence of upwelling and relaxation flow features and dynamics. The detail of these flow patterns, as revealed by CODAR, have important consequences for larval transport and phytoplankton dynamics in the area. These consequences will be explored by WEST and by BML over the next few years.

OS41O-09 1055h

Spatial and Temporal Variability in Bio-Optical Properties During Extremes in Upwelling and Relaxation from the CoOP WEST Study

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The NSF sponsored CoOP (Coastal Ocean Processes) WEST (Wind Events in Shelf Transport) experiment investigates the shelf upwelling paradox that while eastern boundary shelves are characterized by high productivity due to upward fluxes of nutrients into the euphotic zone, wind forcing also represents negative physical and biological controls via offshore transport and deep (light-limiting) mixing of primary producers. We are providing real-time remote sensing products in support of the WEST program in northern California. Our remote-sensing component provides a mechanism for coupling the high temporal resolution (mooring) and process-study (cruises) efforts with a more synoptic view of the coastal ocean, through data products and model development. In addition to the "standard" products such as temperature and biomass (chlorophyll), we are also fine-tuning regional algorithms for prediction of biological parameters such as new (or export) production and primary production.

We have completed two month-long spring cruises, June 2000 and June 2001, centered on the region west of Bodega, CA. The June 2000 cruise period experienced abnormally calm winds and a prolonged relaxation event, while the June 2001 cruise experienced abnormally windy conditions, providing the two possible end-members in an upwelling dominated system. This presentation will provide preliminary results from the shipboard and remotely sensed bio-optical data, with an emphasis on our ability to provide unique near-real time products such as primary and new production under these two very different conditions.

OS41O-10 1110h

The Response of Phytoplankton Processes to Wind Events and Upwelled Nutrients During the CoOP-WEST Study

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In the coastal waters off northern California, seasonal wind-driven upwelling supplies abundant nutrients and CO2 to be processed by phytoplankton productivity. The quantity, quality and fate of the phytoplankton are important in determining the degree of biogeochemical transformation of these materials. As part of the CoOP WEST (Wind Events and Shelf Transport) study we measured nutrients, pCO2, size-fractionated chlorophyll, phytoplankton community structure, flow cytometry of all phytoplankton and nutrient uptake in the upwelling region off Bodega Bay, CA during May-June 2000 and 2001. The ability of this ecosystem to assimilate dissolved inorganic nitrogen and silicon and convert it to particulate material (i.e. phytoplankton) was observed as diatom blooms over the shelf that reduced the ambient nutrients to detection levels. This was particularly effective in the 2000 study when there was a longer period of relaxation. The situation with constant winds and little relaxation occurred in 2001, when nutrients stayed high, the majority of phytoplankton cells were picoplankton (likely Synechococcus from flow cytometry results) that did not reduce the ambient nitrate levels. Molecular gene probes for cyanobacterial and diatom carbon fixation and nitrogen assimilation will be used to establish clearly the agents of nitrogen and carbon transformation in these coastal waters.

OS41O-11 1125h

Response of Euphausiid Populations to Wind Events off Northern California During Summer 2000 and 2001: Results from CoOP/WEST

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Euphausiids are a major component of the zooplankton community in the upwelling environment of the California Current. The objective of this study was to determine the effects of small-scale wind events on euphausiid populations over the continental shelf off Bodega Bay, California during May/June of 2000 and 2001. Wind and current data were collected from moorings and coastal CODAR sites. Euphausiids were collected using 60cm bongo nets with 335μm and 500μm mesh, identified to species, enumerated, and stage of oocyte development noted. Euphausiid community composition showed both along shelf and cross shelf variability. During both 2000 and 2001, *Thysanoessa spinifera* was dominant in inshore waters (<100 m) while *Euphausia pacifica* was dominant in outer shelf and offshore waters (>100 m). Winds during May/June 2000 were of below average strength, with few upwelling events and long periods of relaxation, while winds during May/June 2001 were stronger and more prolonged, leading to more upwelling and fewer relaxation events. These differences in winds appeared to affect the euphausiid community composition and density, as well as oocyte development within ovaries. During the higher wind year of 2001, the range of *T. spinifera* was extended further offshore and to the south of the study area, suggesting that strong northerly winds advected *T. spinifera* offshore and to the south. During the lower wind year of 2000, euphausiid density was greater, especially after a prolonged relaxation of winds, compared to the high wind year of 2001. Preliminary data also shows that numbers of mature oocytes per ovary of *E. pacifica*, differ both cross shelf during 2001 (lower offshore) and

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between years in offshore populations (lower in 2000). These results suggest that while strong winds drive the upwelling and productivity of this system, sustained strong winds are at the same time detrimental to euphausiid population maintenance on the inner and middle shelf.

OS41O-12 1140h

Temporal Variability of Wind: Effects on Primary and Secondary Production in a Simplified Coupled Biological-Physical Model

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One of the primary goals of CoOP WEST (Wind Events and Shelf Transport) is to understand how temporal wind variability influences primary and secondary production on the northern California shelf. We present results from several NPZ models, under various wind forcing scenarios, embedded within a simplified physical model designed to capture the dominant wind processes likely to be important in this system. The physical model represents upwelling as a series of nutrient-rich parcels moved to the surface in a conveyor-belt fashion. Upon reaching the surface, the parcels are transported cross-shore and subjected to vertical mixing using the PRT scale to set the depth of the surface mixed layer. Both synthetic and real wind time series are used to explore the effects of the magnitude, duration and frequency of upwelling favorable winds upon primary and secondary production within the NPZ models . The countervailing effects of high winds supplying nutrients to the surface at a high rate, while reducing light availiabilty by increasing the depth of the mixed layer and transporting nutrients and plankton off the shelf, are examined.

OS41P HC: 315 Thursday 0830h

Climate Impacts on Estuaries and Nearshore Environments

Presiding: **W Kimmerer,** Romberg Tiburon Center**; J A Newton,** Washington State Dept. Ecology

OS41P-01 0830h

How Will Climate Change Affect the Ecosystem of the San Francisco Estuary?

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Recent developments in forecasting have improved confidence in quantitative predictions of global warming and a rise in sea level. However, scaling these forecasts down to regional and local effects may increase uncertainty in three ways: high uncertainty of regional responses to global effects, influence of local anthropogenic effects, and opposing effects of likely mechanisms. For example, precipitation in central California can either increase or decrease with increasing sea surface temperature. Similarly, several effects of regional climate on seasonal timing of precipitation may offset each other. These potential influences on the estuary should be considered in the regional context, such as the evidence of drought periods within the last few millennia of much longer duration than those in the historical record.

Except in the case of a catastrophic drought, local anthropogenic effects may have a greater influence on the San Francisco Estuary than those arising through regional or global influences. Known human influences include a long-term reduction in sediment, historical and current inputs of contaminants, introduction of invasive species, modification of freshwater flow regimes, and large-scale restoration efforts. In addition, it is reasonable to anticipate an increase in urban population and land use, construction of infrastructure, idling of farmland, and future introductions of invasive species.

Attempting to predict the net effect of all these changes on the estuarine ecosystem reveals several difficulties. For example, rising sea level combined with an increase in strong wind events and storm surges should increase resuspension and erosion. The net effect is complicated by the ongoing net sediment deficit, which should increase water clarity, with a consequent increase in phytoplankton growth rates and nutrient uptake. However, changes in the overriding influence of benthic filter-feeding on phytoplankton cannot be predicted. Responses of higher trophic levels will probably be even more complex. Striped bass may survive poorly when the ocean is warm, but estuarine conditions and hatchery production could offset that effect. Chinook salmon may be affected by a variety of pathways, but an increase in air and therefore river temperature, a shift toward earlier spring runoff, and an increase in sea surface temperature may all contribute to decreasing populations. However, changes in management and hatchery practices or habitat restoration may offset some or all of these changes. Without considering the multiplicity of causal pathways and uncertainties in each, predictions of even the sign of long-term changes in the estuarine ecosystem will remain elusive.

OS41P-02 0845h

Sensitivity to Climate Variability in a Box Model of Puget Sound Circulation

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A prognostic, time-dependent box model of Puget Sound, Washington is developed in order to investigate sensitivity to variability of river input and ocean salinity. These forcing factors have a large degree of interannual variability and are influenced by larger climate signals such as ENSO and the PDO. By varying forcing, the model can study the local effects of various scenarios of climate variation on circulation, resolving inter-basin differences. The circulation is modeled as two layer exchange flow, for six basins, three receiving river input and two connecting to the Strait of Juan de Fuca, the outlet to the ocean. Advective fluxes are determined by a combination of the Stommel approximation and by conservation of mass and salt. Model salinities exhibit a seasonal cycle consistent with a composite of 1990s monthly salinity data for each basin. This is achieved with parameterized forcing functions based on salinity data from the eastern Strait of Juan de Fuca and river flow from USGS historical stream gauge data over the same time period. Amplitude variation of peak river flows significantly affect only the basin into which they enter and their effects are limited to the time of perturbation. All of the basins are sensitive to changes in forcing salinity; the responses are rapid and persist past a return to the unperturbed salinity.

OS41P-03 0900h

Climte Variability, Mississippi River Discharge, and Hypoxia in the Gulf of Mexico

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Extensive areas of hypoxic bottom water form seasonally on the continental shelf of the northern Gulf of Mexico. The size is minimal during drought and large, up to 20,000 sq km, during periods of high flow and nitrate flux. Hypoxia is related to the discharge and nitrate flux of the Mississippi River system and is influenced by climate variability. Simple regressions relate the 2-dimensional extent of hypoxia to freshwater or nitrate flux for May in the current year, and more closely to integrated flow or nitrate flux for the 75-d period before the shelfwide mapping of hypoxia. The 75-d period is based on an average freshwater fill time for the shelf. This integrative factor captures the complexity of the biological/physical interactions of carbon production and flux, respiratory consumption of oxygen, stratification, and currents prior to deriving the estimated size of the zone in mid-summer during a 5-day cruise. We examine these relationships with the estimated size of the hypoxic zone for the period 1985-2001 as reported previously, from computer generated contours of the hypoxic zone size, for volume estimates from the same cruises, and for independently derived estimates from SEAMAP and other cruises.

OS41P-04 0915h

Interannual variability of circulation and hydrography in Puget Sound, Washington and its relationship to the regional climate, 1933 - Present

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Historical and contemporary hydrographic data from various locations in Puget Sound, Washington are analyzed for signals of variability with interannual and longer time scales, and compared with indices of regional and global climatic regimes. For each variable, a canonical seasonal cycle is constructed from a yearly composite, then subtracted from the raw time series to obtain an anomaly time series. In order to exclude aliasing of high-frequency variability, anomaly time series from multiple locations are compared and combined for an anomaly series representing the entire Sound.

Temperature anomaly time series show no overall trend in the Sound's waters for the period but shows significant correlation with the Pacific Decadal Oscillation (PDO) Index, indicating that the Sound's temperatures reflect that of the regional climatic regime. Salinity anomaly time series show influence of regional precipitation/river discharge and oceanic conditions along the Pacific coast of Washington and Oregon. Anomalously high wintertime salinity values are observed in drought winters such as year 2000; however, high river discharge does not necessarily result in anomalously fresh conditions. Instead, fresh anomalies appear to result from reductions of upwelling water arriving from the Pacific coast, which may occur in years of anomalous atmospheric circulation associated, for example, with El Nino. A quantitative assessment of the Sound's hydrographic conditions in relation to these and other climate indices will be reported.

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Climate Impacts on Primary Production and Water Properties of Pacific Northwest Estuaries.

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Modes of climate variability, such as El Nino-Southern Oscillation and Pacific Decadal Oscillation, are known to affect local weather in the Pacific Northwest. The impacts of variable weather patterns on water properties and biological properties in PNW estuaries, however, are not well known. Some of the emerging patterns are that upwelling intensity and the depth of the coastal ocean thermocline are important factors governing estuarine water properties such as dissolved oxygen, nutrients, and phytoplankton biomass. Effects of river flow and local air temperature are also important but vary as to relative impact on spatial (i.e. different estuaries) and temporal (i.e. seasonal) scales. The recent 1997-1998 El Nino and the 1999 and 2000 La Nina events were observed to exhibit strong effects on two PNW estuaries, Puget Sound and Willapa Bay. In general, colder, saltier waters and higher chlorophyll and primary production were representative of the post 1998 data, and these were associated with a shallower ocean thermocline and upwelling favorable winds. Primary productivity and biomass in Willapa Bay during 1997-1998 were 60-70 percent of 1999 and 2000 values although nitrogen limitation was evident for all years. This difference was less profound in some parts of Puget Sound. Regional responses varied regarding the balance between oceanic, watershed, and local forcings for different PNW estuaries and sub-basins.